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Visual Landmarks Systems for Humanoid Robots

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Abstract

In this paper, we consider a model of visual landmarks selection for humanoid robots navigation. This model is based on a genetic programming approach.

Keywords: humanoid robots, visual landmarks, mobile robot navigation

Problems of mobile robot navigation has remained as a subject of intense study for many decades (see e.g. [1] – [11]). In particular, visual landmarks systems has been extensively investigated for mobile robot navigation (see e.g. [12] – [16]). However, most of the well-known approaches to visual landmarks navigation were created and demonstrated on wheeled robots.

Note that many humanoid robots used visual landmarks systems. In particular, we can mention HRP-2 [17]. HRP-2 is fitted with a high-performance forward-looking trinocular camera rig. This camera provides the capability to make accurate 3D measurements in a focused observation area close in front of the robot. HRP-2 uses visual landmarks and monocular SLAM. A reinforcement learning method for visual landmarks navigating the Nao was presented in [18]. Reem-B uses two lasers [19]. Reem-B is able to construct a map and localize on it. Navigation of Reem-B is mainly guided by laser data. Visual landmarks used only as auxiliary method.

However, traditional approaches to visual landmarks navigation are insufficiently effective for humanoid robots. Usually, we need some additional constraints that keep some landmarks. In particular, the problem of placement of visual landmarks was proposed in [12]. The problem of selection of a minimal set of landmarks was proposed in [13]. This models are quite effective for wheeled robots. But, this models are insufficient reliable for humanoid robots. Humanoid robots have many more degrees of freedom. Even on a flat surface, a camera will have much variation in its positioning. For humanoid robots, we obtain much greater noise and difficulty in interpreting a stream of images.

For humanoid robots, we need redundant set of visual landmarks. This redundancy allows us to compensate the loss of some visual landmarks. We assume that

$$(x_i, y_i, z_i)$$

is a position of some landmark. In this case, we can consider a function

$$R_i((x_1, y_1, z_1), (x_2, y_2, z_2), \ldots, (x_m, y_m, z_m)) =$$

$$\sum_{1 \le j \le t} \delta_j \prod_{i=1}^{m} x_i^{\alpha_{i,j}} \prod_{i=1}^{m} y_i^{\beta_{i,j}} \prod_{i=1}^{m} z_i^{\gamma_{i,j}}$$

as a redundancy function for (x_i, y_i, z_i).

We consider a redundancy function for (x_i, y_i, z_i) as a unification of the probability of disappearance of landmark and the probability of usage of landmark. We consider

$$t, \delta_1, \delta_2, \ldots, \delta_t, \alpha_{1,1}, \ldots, \alpha_{m,t}, \beta_{1,1}, \ldots, \beta_{m,t}, \gamma_{1,1}, \ldots, \gamma_{m,t}$$

as chromosome and use a genetic algorithm to construct a set of redundancy functions. After this, we use a model of genetic programming based on the set of redundancy functions to construct a redundant set of visual landmarks. This model evolves a set of rules of the following form:

$$[i; \{R_i \mid i \in I\}] \to H_i = \{R_i \mid i \in J\}$$

where $J \subseteq I$.

We assume that if a landmark (x_i, y_i, z_i) needed for a humanoid robot localization, then the robot can use any landmark from H_i instead (x_i, y_i, z_i). Also, we assume that a robot can find at least one landmark from H_i with a sufficiently high probability.

In our computational experiments, we have compared the quality of considered model of genetic programming based on the set of redundancy functions

average number of generations	10^3	10^4	10^5	10^6
number of landmarks for GP+GA	46 %	32 %	2.1 %	0.7 %
number of landmarks for GA	52 %	35 %	24 %	22 %

Table 1: Average number of landmarks for GP+GA and GA.

average number of generations	10^3	10^4	10^5	10^6
probability of failure for GP+GA	7 %	6 %	0.32 %	0.07 %
probability of failure for GA	3 %	2 %	1.9 %	1.63 %

Table 2: Probability of failure for GP+GA and GA.

(GP+GA) and the quality of a genetic algorithm for direct prediction of a redundant set of visual landmarks (GA). Selected experimental results are given in Tables 1 and 2.

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